PREDICTIONS FOR THE FRACTURE TOUGHNESS OF CANCELLOUS BONE OF FRACTURE NECK OF FEMUR PATIENTS

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Introduction

Current protocol in determining if a patient is osteoporotic and their fracture risk is based on dual energy X-ray absorptiometry (DXA). DXA gives an indication of their bone mineral density (BMD) which is the product of both the porosity and density of the mineralized bone tissue; this is usually taken at the hip. The DXA results are assessed using the fracture risk assessment tool as recommended by the World Health Organization. While this provides valuable data on a person's fracture risk advancements in medical imagining technology enables development of more robust and accurate risk assessment tools. In order to develop such tools in vitro analysis of bone is required to assess the morphological properties of bone osteoporotic bone tissue and how these pertain to the fracture toughness (Kc_{max}) of the tissue.

Materials and Methods

In a previous study the Kc_{max} was determined *in vitro* and compared with *in-vitro* apparent density and *in vivo* DXA measurements (Cook & Zioupos, 2009). Sixty one samples were taken from 37 osteoporotic and 13 osteoarthritic patients ranging from ages 59-96 years. The samples were taken from the centre of the femoral head and cut into a disks conforming to ASTM standard E399-90 to be used in determining the plane-strain fracture toughness. These samples have been imaged using μCT (XT H 225, X-Tek Systems Ltd) and from the 3D images various morphological parameters could be determined. Using these morphological parameters along with the measured fracture toughness multilinear regression analysis could be performed to determine a "model" for fracture toughness in cancellous bone.

Results

Using multi regression analysis on the morphological data the terms that have a significant impact on the measured facture toughness were identified. Determining coefficients lead to equation (1) where BV/TV is the bone volume ratio, BS/TV in the specific surface and TbN in the average number of trabecular.

$$FT = 1.708\left(\frac{BV}{TV}\right) - 0.278\left(\frac{BS}{TV}\right) + 0.759(TbN) - 0.348 \qquad (1)$$

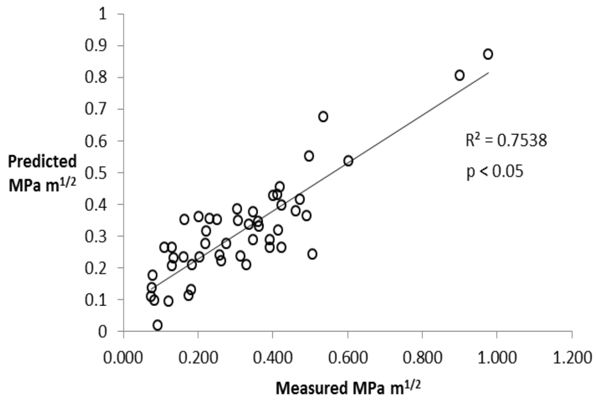

Figure 1: Predicted Kc_{max} vs measured Kc_{max} from human osteoporotic and osteoarthritic cancellous bone

Discussion

The research shows that a model to predict fracture toughness can be developed using multi linear regression in conjunction with data obtained from micro-CT imaging, further terms can be added to the model to increase its accuracy. The next is to down sample the data to increase the voxel size, effectively reducing the resolution in order to determine the minimum resolution required for statistically significant analysis. This in turn will provide either a 'target' resolution that medical scanner will have to reach to be able to predict cancellous bone fracture toughness or maybe show that current state of the art scanners are currently capable of high enough resolution to produce a valid fracture toughness model based on morphological data.

References

1. Cook, R. B., & Zioupos, P. J Biomech, 42: 2054–60, 2009
2. Cook RB, et al Med Eng & Physics, 32: 991-7, 2009

Acknowledgements

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